Formation of hydrothermal corrugations during ultramafic rocks weathering

Laurent Guillou-Frottier, Anicet Beauvais, Robert Wyns, Laurent Bailly, Thierry Augé, Anne-Sophie Audion

Formation de corrugations hydrothermales lors de l'altération des roches ultramafiques

Laurent GUILLOU-FROTTIER[(1)], Anicet BEAUVAIS[(2)], Robert WYNS[(1)], Laurent BAILLY[(1)], Thierry AUGE[(1)],, Anne-Sophie AUDION[(3)]
(1) BRGM, ISTO, UMR 7327, Orléans ; (2) Aix-Marseille Université, CEREGE (IRD, CNRS), Aix-en-Provence ; (3) Variscan mines, Orléans
l.guillou-frottier@brgm.fr

Préférence pour : ☒ Présentation orale, ☐ Poster, ☐ Sans préférence

During shallow subsurface (< 200 m depth) weathering processes, temperatures may reach several tens of °C as a result of exothermic chemical reactions, such as hydration of olivine in ultramafic rocks or chloritization of biotite in granitic rocks. These mineralogical transformations enhance mineral fracturing, and the growth of fracture networks leads to further reactions and increases the permeability. The subsequent deepening of the weathering front creates new reactions, thus self-maintaining the weathering process over several million years (Myr). For more than 20 Myr, the peridotite massifs of New Caledonia have undergone intense weathering that has produced thick lateritic weathering mantles. The observable undulations of the weathering front and the protrusions of unweathered peridotite, from several meters to several tens of meters high, attest to a corrugated bedrock topography, which may result from inhomogeneous fluid circulation patterns within the coarse, permeable and porous (30-50%) saprolite layer. Combined together, the excess heat (up to ≈ 100°C) and high permeability (10^{-14} to 2×10^{-13} m²) within lateritic weathering mantles could potentially trigger hydrothermal convection (buoyancy-driven flow). This was numerically modeled by accounting for temperature-dependent fluid density and viscosity, and for time-dependent and spatially varying parameters simulating the deepening of the weathering front. Modeling the transient evolution of the thermal and flow velocity fields over 10 Myr reveals that hydrothermal convection can be triggered in the weathering lateritic mantles of New Caledonia, even on sloped surfaces where topography-driven flow prevails. Convective cells develop above the weathering front, and the amplitudes of thermal undulations are enhanced when feedback mechanisms between permeability and temperature are accounted for. The models also allow definition of the most probable zones of mineralization and reveal two-dimensional corrugations below which weathering is no longer efficient.